Student Workbook

California Education and the Environment Initiative

E

Earth Science Standard E.5.d.

# Ocean Currents and Natural Systems

**California Education and the Environment Initiative**

Approved by the California State Board of Education, 2010

**The Education and the Environment Curriculum is a cooperative endeavor of the following entities:**

California Environmental Protection Agency

California Natural Resources Agency

Office of the Secretary of Education

California State Board of Education

California Department of Education

California Integrated Waste Management Board

**Key Leadership for the Education and Environment Initiative:**

**Linda Adams,** Secretary, California Environmental Protection Agency

**Patty Zwarts,** Deputy Secretary for Policy and Legislation, California Environmental Protection Agency

**Andrea Lewis,** Assistant Secretary for Education and Quality Programs, California Environmental Protection Agency

**Mark Leary,** Executive Director, California Integrated Waste Management Board

**Mindy Fox,** Director, Office of Education and the Environment, California Integrated Waste Management Board

**Key Partners:**

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**Office of Education and the Environment**

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**http://www.calepa.ca.gov/Education/EEI/**

# Contents

**Alginate:** A carbohydrate found in certain brown algae, such as kelp, that is used commercially as a stabilizer for many products including ice cream.

**Biomass:** The total mass of living matter in a given area; or, plant material (wood, grains, agricultural waste, vegetation) sometimes used as an energy source.

**Breakwater:** A structure built by humans to protect a bay or harbor from wave action.

**California Current:** A cold, slow current that flows southward from Alaska along the California coast to northern Baja California.

**California Department of Fish and Game:** The agency responsible for the management of California's diverse natural resources and natural communities, as well as the diversified use of fish and wildlife for recreation, commerce, science, and education.

**Cyclic temperature fluctuation:** Long-term patterns of temperature change that are repeated.

**Distribution:** The geographic area inhabited by a species.

**Dredging:** The use of heavy equipment and machinery to remove sediments from one location and transport them to another.

**Filter feeder:** An organism that feeds on particles of suspended matter by straining them from water.

**Fishery:** An ocean region where humans harvest or raise marine animals, such as fish and invertebrates. It is also used to refer to the processes of harvesting and raising marine animals.

**Gyre:** A global circular motion of ocean currents that flow clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

**Habitat destruction:** Damaging a habitat by removing plants, disturbing the soil, or substantially changing other parts of the natural system.

**Jetty:** A coastal structure that runs perpendicular to the shoreline, built by humans to influence currents, and protect harbors and coastal areas.

**Kelp:** Large brown algae that grow primarily in shallow ocean water in temperate and arctic regions.

**Latitude:** An angular measurement of the distance north or south from the Equator.

**Longshore current:** A current that runs parallel to the shore and carries sediments along the coastline.

**Natural system:** The interacting components, processes, and cycles within an environment, as well as the interactions among organisms and their environment.

**Overfishing:** Harvesting a fish species faster than its population is replenished by reproduction.

**Pacific sardine (*Sardinops sagax*):** A species of fish found in coastal areas of the eastern Pacific Ocean that filter feeds on phytoplankton and small zooplankton.

**Phytoplankton:** Plankton, such as diatoms and dinoflagellates, that are capable of producing food energy through photosynthesis.

**Plankton:** Any organism in fresh or sea water that passively drifts with currents. Plankton range in size from microscopic bacteria to large jellies.

**Population:** The number of individuals of one or more species living in a place at a given time.

**Primary productivity:** The conversion of solar energy to organic material that is synthesized through photosynthesis and chemosynthesis and is available to organisms in an ecosystem.

**Resource management:** The management or restoration of natural resources, such as ecosystems, to maintain or improve the condition of the natural system or a particular resource.

**Salinity:** The total amount of salts dissolved in water; sea water averages 35 parts per thousand.

**Scientific research:** Investigations conducted according to the principles and methods of science, including the empirical testing of hypotheses.

**Seasonal thermocline:** The seasonal change in water temperature caused by increased solar radiation in the spring and summer, that results in the presence of a thermocline.

**Sustainable population:** A population of organisms that is large enough to maintain itself for a long time.

**Thermocline:** A vertical gradient in the ocean or a lake characterized by a rapid change of temperature with depth.

**Upwelling:** The wind-driven movement of cold, usually nutrient-rich water from ocean depths to the surface.

**Variable:** A factor or function that changes in response to varying conditions or over time.

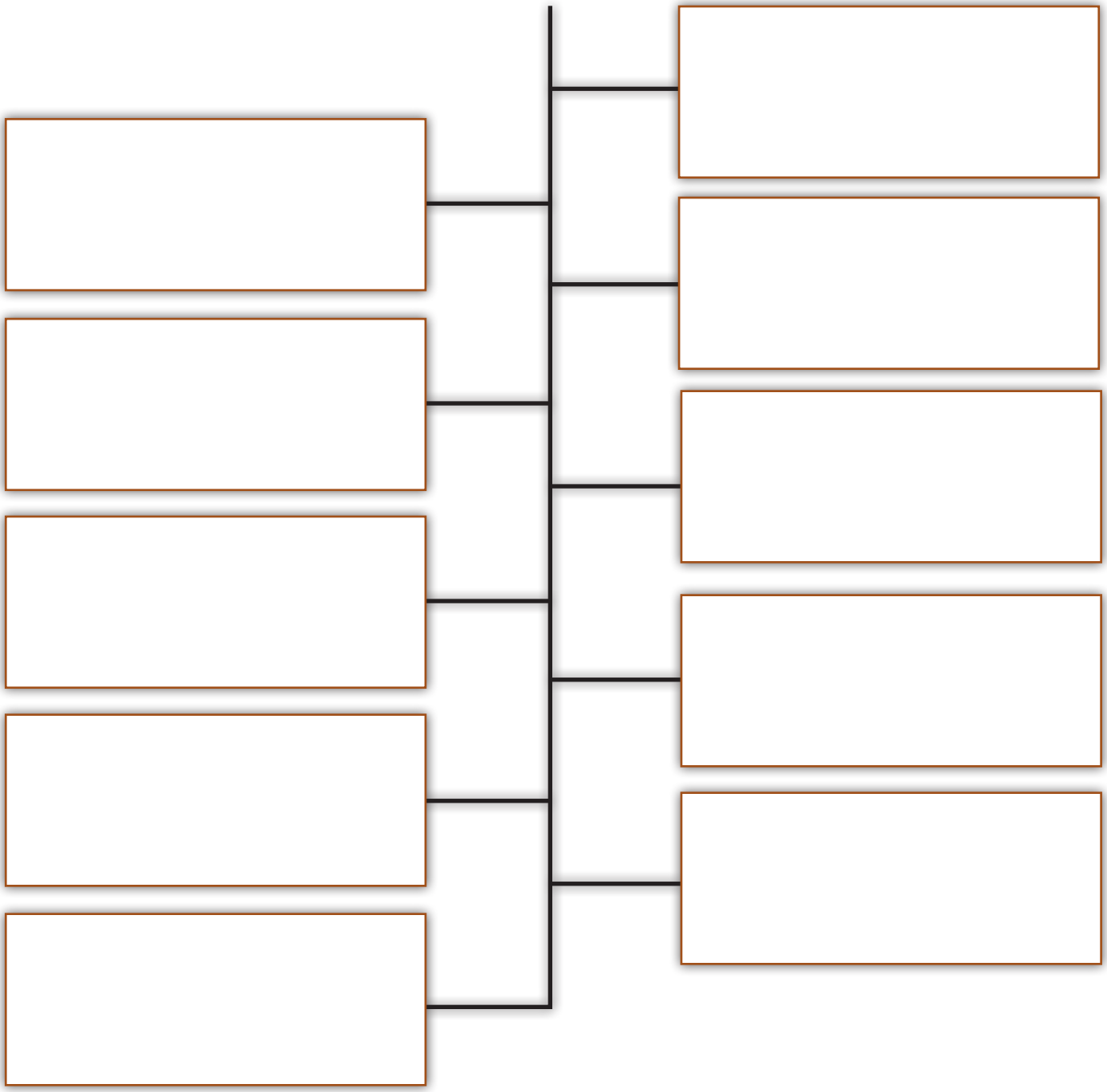
**Vertical current:** The movement of water from deeper depths to the surface, as in upwelling or convection.

**Vertical layering:** The layers of water in a lake or the ocean that result from differences in temperature and density.

**Zooplankton:** Animals, such as copepods, jellies, and fish larvae, that are part of the plankton that drift with currents.

Name: _____

**Instructions:** Complete the timeline of events in the history of the sardine industry based on your reading of ***California Connections: Packed Like a Can of Sardines*** (Student Edition, pages 2–5). Use the **California Sardine Industry Timeline Scoring Tool** on the next page to guide your responses.



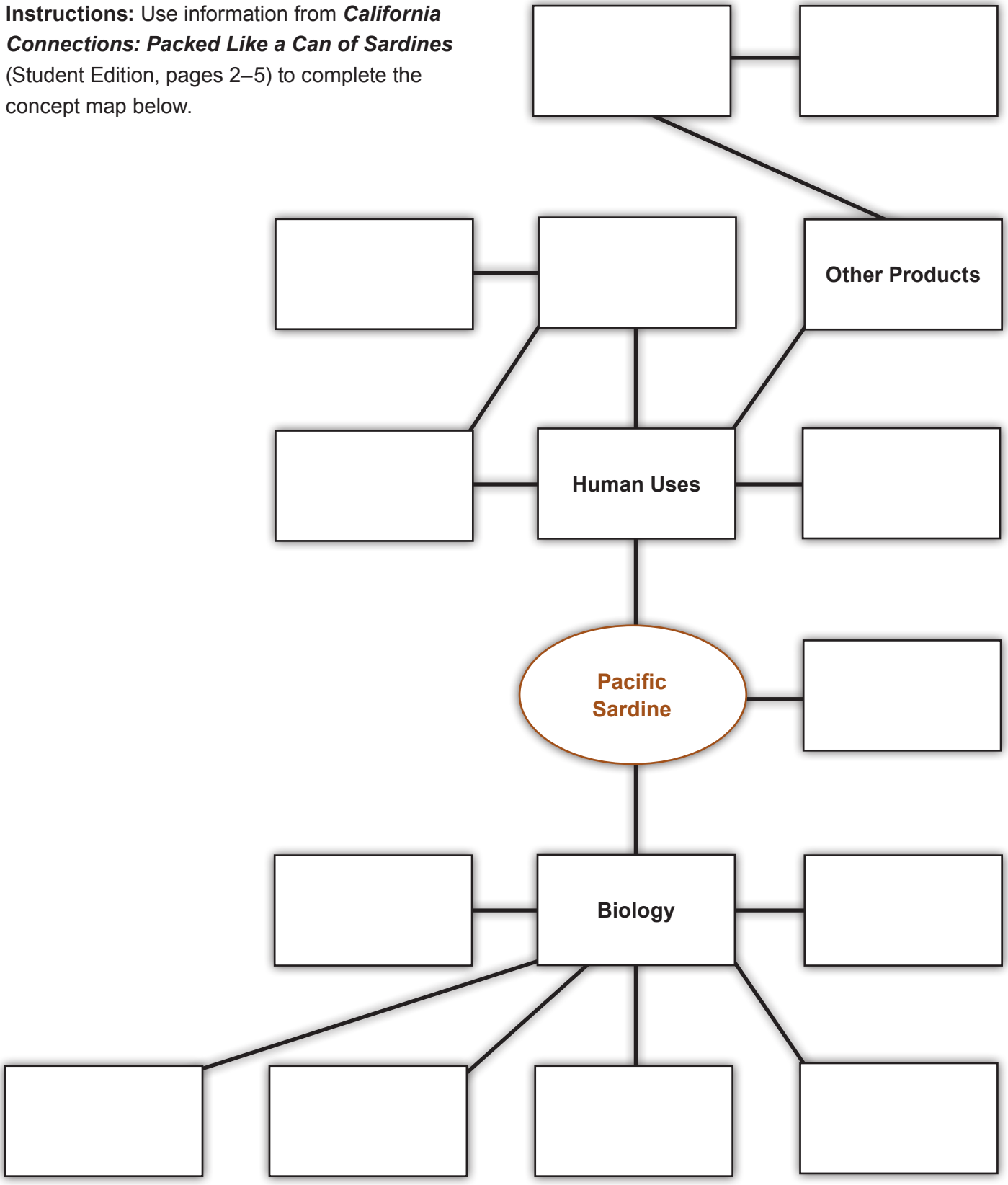
Name: _____

## California Sardine Industry Timeline Scoring Tool

| Component | 5 Points | 3 Points | 1 Point |
|---|---|---|---|
| **The sequence is correct, starting in the 1800s and ending in present day.** | | | |
| **The information presented in *California Connections: Packed Like a Can of Sardines* is represented on the timeline.** | | | |
| **The interactions with humans are represented through the presentation of historical facts.** | | | |

Name: _____

**Instructions:** Use information from ***California Connections: Packed Like a Can of Sardines*** (Student Edition, pages 2–5) to complete the concept map below.

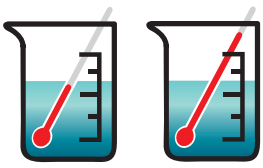
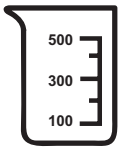


Name: _____

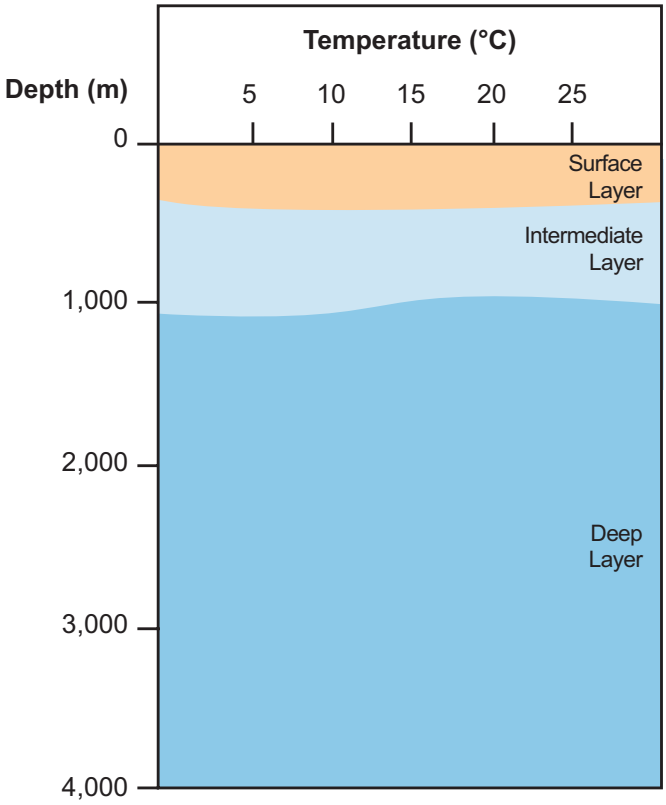
**Instructions:** Read the following prompt while looking at the **Structured Ocean Layering Diagram** and participate in a class discussion about the causes of differences in ocean water temperatures, density, and mixing.

The ocean primarily forms layers because water with a higher density sinks below water with a lower density. In the ocean, two important variables govern water density: temperature and salinity. In this demonstration you will observe how one of these variables, temperature, affects the layering of a body of water.

## Materials Needed

| | |
|---|---|
| **Two thermometers**  | **One 500 and one 100 ml beaker**   |
| **Ice cubes**  | **Bottle of food coloring**  |
| **Three glass containers**  | **Plastic wrap**   |

## Structured Ocean Layering Diagram



Name: _____

**Instructions:** You will investigate what happens when waters of different temperatures meet. Write a hypothesis about whether water at different temperatures will mix or form layers, and if it forms layers, what will happen to warm water in comparison to cool water. Use information from the class discussion and what you already know about the density of water at different temperatures to help you form your hypothesis.

My hypothesis about how what will happen when water at two different temperatures comes in contact is:

| Trial Number | Water Temp. (°F) | Water Temp. (°F) | Water Temp. (°F) | Observations |
|---|---|---|---|---|
| **1** | Water on bottom layer _____ | Water on top layer _____ | Water after mixing _____ | |
| **2** | Water on bottom layer _____ | Water on top layer _____ | Water after mixing _____ | |
| **3** | Water on bottom layer _____ | Water on top layer _____ | Water after mixing _____ | |

Name: _____

**Instructions:** Use the data from the chart on the previous page to complete the following tasks in the spaces provided.

1. What happened to the water when you removed the plastic wrap?

2. Describe the mixed layer.

3. What happened to the mixed layer as the temperature of the water masses began to equalize?

Name: _____

**Instructions:** Answer the following questions in the spaces provided. (5 points each)

1. Why does warmer water float on colder water?

2. Did you observe any mixing of the layers? Explain.

3. Does mixing occur in the ocean? Explain.

4. How could the properties of the ocean water you observed in this demonstration affect the geographic distribution of coastal and marine organisms?

Name: _____

**Instructions:** Select the best answer and circle the correct letter.

1. Off California's coast, a thermocline _____.

a. disappears during the summer
b. forms during the summer, as the California Current brings cold water to form an upper layer
c. forms during the summer, as increased sunlight heats the upper layers of the water
d. remains constant all year round

2. In polar regions, phytoplankton _____.

a. thrive all year round, because nutrients are always plentiful
b. thrive during the summer, when sunlight increases
c. cannot survive, because the waters are too cold
d. cannot survive, because a permanent thermocline traps nutrients deep below the surface

3. In tropical regions, _____.

a. a permanent thermocline traps nutrients in the deep water
b. primary productivity is high all year round, because there is a constant supply of solar energy for photosynthesis
c. the thermocline disappears in the winter
d. the upper and lower layers of water mix all year round

**Instructions:** Complete the following tasks in the spaces provided.

4. Explain how a seasonal thermocline creates vertical layering off California's coast.

Name: _____

5. Why is ocean layering seasonal off California's coast?

6. How does seasonal vertical layering influence distribution of primary producers and other organisms?

7. How does the movement of currents off California's coast affect the distribution of marine organisms?

Name: _____

**Instructions:** Complete the following tasks in the spaces provided. (5 points each)

1. Describe a breakwater, its function, and how it works.

2. Describe a jetty, its function, and how it works.

3. What are three reasons to build jetties or breakwaters?

4. Identify and describe two effects on the natural environment resulting from construction of a jetty or breakwater.

Name: _____

**Instructions:** Select either the Santa Monica Breakwater or the Huntington Harbor to answer questions 5 and 6. Question 7 relates either to a jetty or a breakwater system. Write your responses in the spaces provided. (5 points each)

5. What is the history of this jetty or breakwater system?

6. How does this system influence local currents?

Name: _____

7. How is sediment transportation affected by a jetty or breakwater system? (Describe both positive and negative effects.)

Name: _____

**Instructions:** Complete the following paragraphs using the words from the Word Bank. (1 point each)

**Word Bank**

| | | |
|---|---|---|
| alginate | nutrients | primary producer |
| increases | solar energy | sunlight |
| reduces | temperate | |
| food source | habitat | |

Kelp is a _____, since it converts _____ to organic energy by photosynthesis. Several physical properties of the ocean promote its growth: kelp requires _____ and _____; and it lives in _____ regions where waters are cool throughout the year. Kelp plays an important role in the ocean. It provides a _____ for many species, such as sea otters that forage and raise babies in the kelp beds. It also acts as a _____ for many organisms, such as the sea urchin.

Kelp harvesting has many effects on both ecosystems and humans. Extensive harvesting _____ populations of fish and other organisms that live in kelp forests. However, harvesting _____ profits for companies that use kelp, such as those that produce _____, an additive used in food and cosmetics.

Name: _____

**Instructions:** Complete the following tasks in the spaces provided. (5 points each)

1. Explain how harvesting the top layer of a kelp forest alters life for the marine organisms that live in this ecosystem.

2. Explain how kelp harvesting can influence human communities and economies.

Name: _____

**Instructions:** Take turns reading the events on the timeline below. Categorize each event as an example of scientific knowledge, management policy, or a management decision in the right-hand column.

| Date | Event | Scientific Knowledge, Policy, or Management Decision |
|---|---|---|
| **1945** | An estimated 550,000 metric tons of sardines caught off the California coast. Catch greater than any other fish catch in North America. Twenty-four canneries operate along Cannery Row. | |
| **1947** | Sardine fishery falls to 100,000 metric tons; and a tax imposed on fishermen to help support scientific research. | |
| **1949** | Research collaborative established to investigate the sardine fishery's collapse. Participants include: Scripps Institution of Oceanography, the NOAA/NMFS Southwest Fisheries Science Center, and the California Department of Fish and Game. This group is later named the California Cooperative Oceanic Fisheries Investigations (CalCOFI). | |
| **1957** | Ocean off California warms by 3.6° F (2° C), causing anomalies in precipitation, plankton abundance, and fisheries. | |
| **1958** | Oceanographers, fishery personnel, and meteorologists conclude that understanding and forecasting fluctuations in coastal fisheries are best achieved by studying the entire ocean and ocean-atmosphere relationships. | |
| **1960** | Approach to sardine question becomes more interdisciplinary and ecosystem based. | |

Name: _____

| Date | Event | Scientific Knowledge, Policy, or Management Decision |
|---|---|---|
| **1963** | First volume of CalCOFI atlas series describes temperature and salinity in the California Current. | |
| **1964** | Sardine spawning biomass in this year (at 30,000 metric tons) is 1% of the spawning biomass of 1938. (Spawning biomass is an estimate of the total weight of the fish population. The sardine biomass estimate is based on a sample of fish eggs and plankton eggs.) State legislature enacts fishery moratorium. | |
| **1969** | By counting fish scales taken from sediment off the Santa Barbara coast, CalCOFI scientists reconstruct an 1,800-year record that shows sardines follow a cycle of decline and recovery approximately every 30 to 60 years. | |
| **1972** | Sardine spawning biomass minimum at less than 10,000 metric tons. | |
| **1977** | Researchers observe long-term changes in sea-surface temperature, ocean circulation, and climate. | |
| **1979** | Egg-production method, a new technique for measuring the size of the fishery, is introduced. | |
| **1982** | Large anomalies in temperature and zooplankton biomass in the CalCOFI data first linked to tropical ocean warming phenomena. | |

Name: _____

| Date | Event | Scientific Knowledge, Policy, or Management Decision |
|---|---|---|
| **1983** | Quick-response study of 1983–1984 El Niño makes it one of the most thoroughly documented El Niño events to date. | |
| **1985** | Sardine spawning biomass reaches 30,000 metric tons; the highest since 1964. | |
| **1986** | California lifts its moratorium on sardine fishing in response to measured increases in spawning biomass. | |
| **1995** | Sardine spawning biomass reaches 300,000 metric tons; the highest since 1954. | |
| **1998** | Significant data compiled on consequences of El Niño to nutrient, chlorophyll, and zooplankton patterns in the California Current, providing a close look at links between ocean physics and biology. | |
| **1999** | Spawning biomass of sardines exceeds 1 million metric tons for the first time since the CalCOFI surveys began in 1951. | |

Name: _____

**Instructions:** Read the prompt and complete the task on the chart below. (10 points)

1. Consider the ways that scientific evidence has been used to make decisions about the sardine industry. Record your ideas in the chart below. On the left, list examples of the kinds of scientific evidence that scientists have collected about sardines and their ecosystems. On the right, list examples of management policies and decisions that have been made about the sardine industry.

| Examples of Scientific Evidence | Examples of Policies and Management Decisions |
|---|---|
| | |

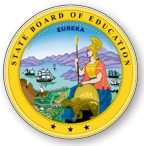
**Instructions:** Answer the following questions and complete the tasks in the spaces provided. (5 points each)

2. How have sardine populations and their ecosystems changed over time? Use scientific evidence to explain your answer.

Name: _____

3. How do scientists explain the decline in sardines that occurred in the 1940s?

4. Give an example of how scientists' understanding of sardine populations influenced a management policy decision.

California STATE BOARD OF EDUCATION

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